The Large Synoptic Survey Telescope

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LSST Director

Snowmass on the Mississippi
July 30, 2013

LSST in a Nutshell

- **The LSST will be a large, wide-field ground-based telescope designed to provide time-lapse digital imaging of faint astronomical objects across the entire visible sky every few nights.**

- **LSST will enable a wide variety of complementary scientific investigations, utilizing a common database. These range from searches for small bodies in the solar system to precision astrometry of the outer regions of the galaxy to systematic monitoring for transient phenomena in the optical sky.**

- **Of particular interest for cosmology and fundamental physics, LSST will provide strong constraints on models of dark matter and dark energy through statistical studies of the shapes and distributions of faint galaxies at moderate to high redshift, and the detections of large numbers of Type Ia supernovae.**

Summary of High Level Requirements

Survey Property	Performance
Main Survey Area	18000 sq. deg.
Total visits per sky patch	825
Filter set	6 filters (ugrizy) from 320 to 1050nm
Single visit	2 x 15 second exposures
Single Visit Limiting Magnitude	u = 23.9; g = 25.0; r = 24.7; I = 24.0; z = 23.3; y = 22.1
Photometric calibration	< 2% absolute, < 0.5% repeatability & colors
Median delivered image quality	~ 0.7 arcsec. FWHM
Transient processing latency	< 60 sec after last visit exposure
Data release	Full reprocessing of survey data annually

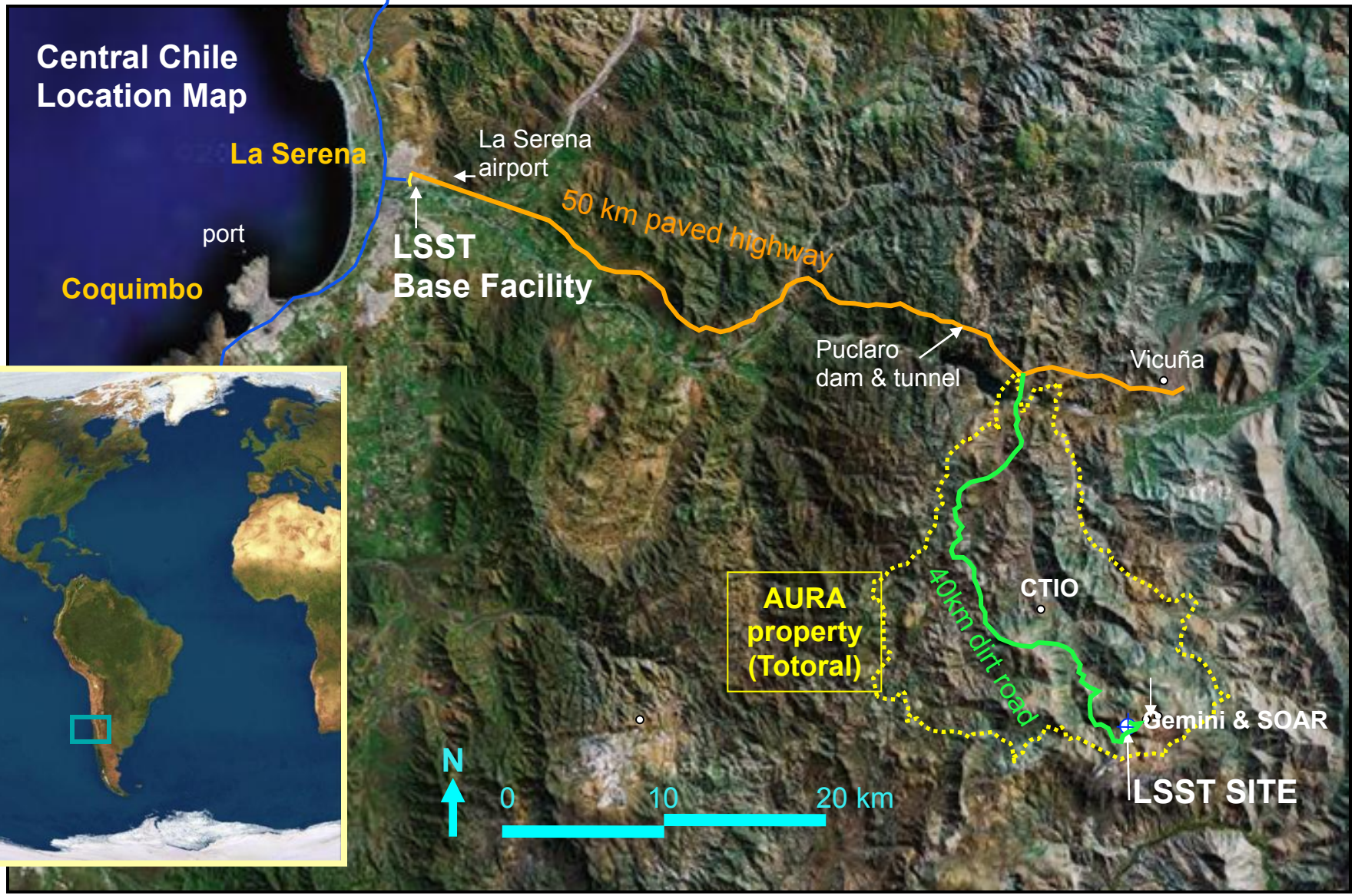
LSST is a Public/Private, Interagency Project

- **The National Science Foundation:**
  - Support for the telescope and site facility construction, the data management system, and the education and public outreach components.
  - Funded under the Major Research Equipment and Facility Construction (MREFC) line. Total projected cost is $466M.
  - Prime contractor for this effort is the Associated Universities for Research in Astronomy (AURA), which also manages the National Optical Astronomy Observatory (NOAO), the Space Telescope Science Institute (STScI), and other facilities.

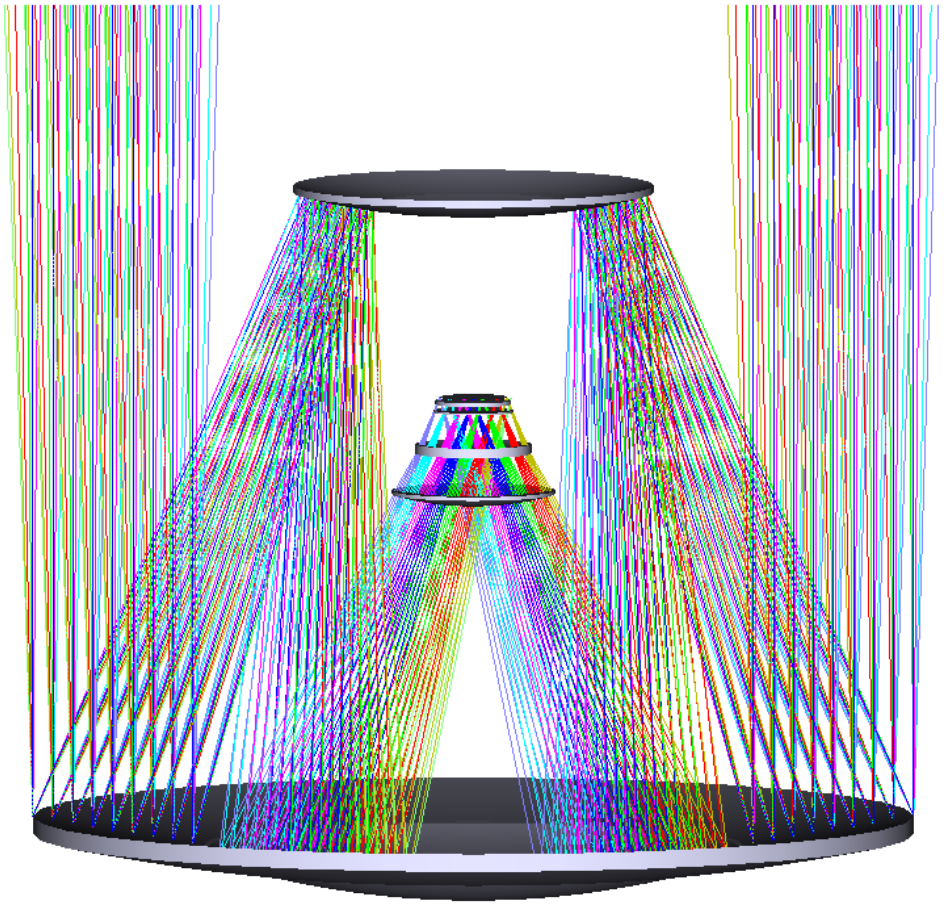
- **The Department of Energy:**
  - Support for the camera fabrication.
  - Funded as a Major Item of Equipment (MIE), through the Office of High Energy Physics in the Office of Science. Total projected cost is $163M.
  - SLAC National Accelerator Laboratory is the lead DOE lab for the LSSTcam project.

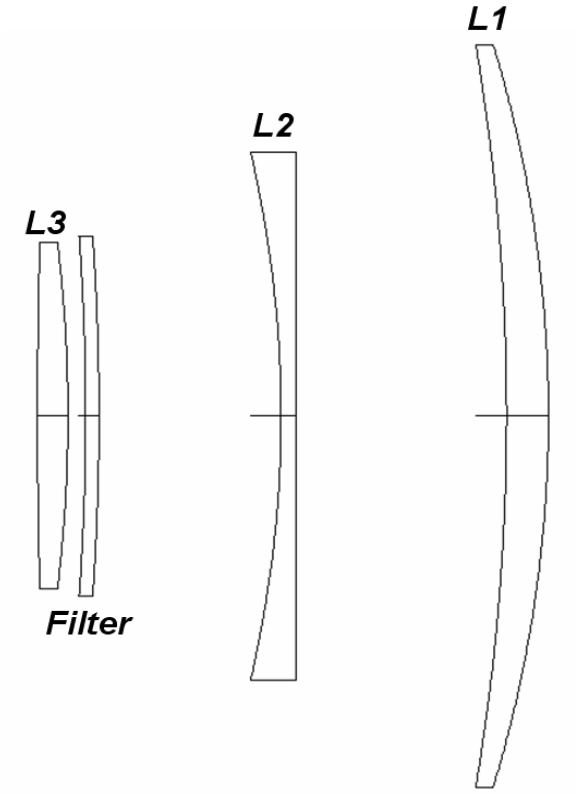
- **Private Support:**
  - Key donors include the Charles Simonyi Fund for Arts and Sciences, Bill Gates, Richard Caris, the W.M. Keck Foundation, Research Corporation for Science Advancement, Wayne Rosing and Dorothy Largay, Eric and Wendy Schmidt, and Edgar Smith.
  - Total Support is ~ $40M.
  - Funded development of the primary/tertiary mirror, the secondary mirror blank, preliminary site preparation, as well as early sensor studies.
  - Responsible organization is the Large Synoptic Survey Telescope Corporation.

LSST Will be Sited in Central Chile

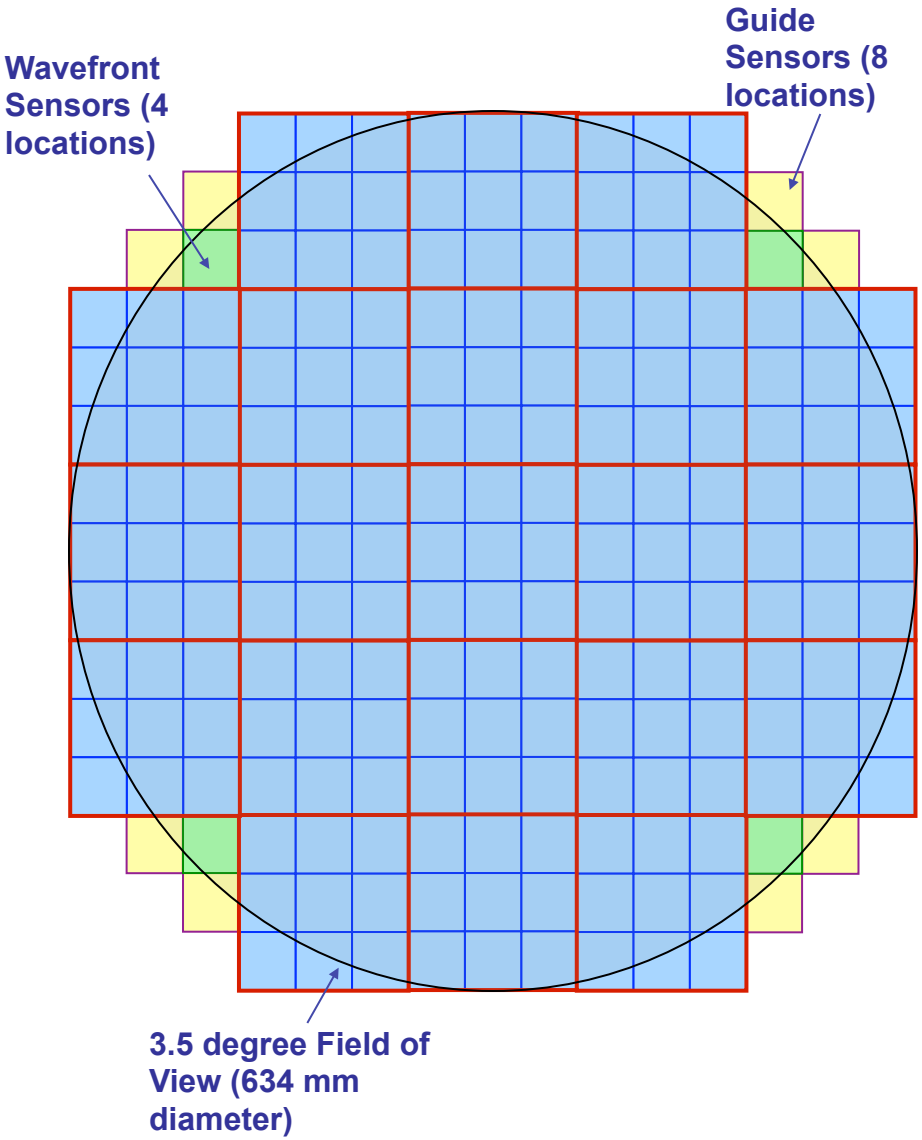


Modified Paul-Baker Optical Design

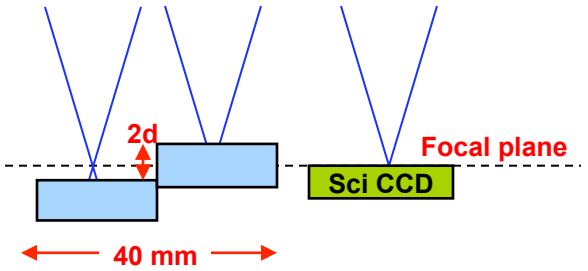




The LSST Focal Plane - 64 cm in Diameter



Wavefront Sensor Layout



Curvature Sensor Side View Configuration

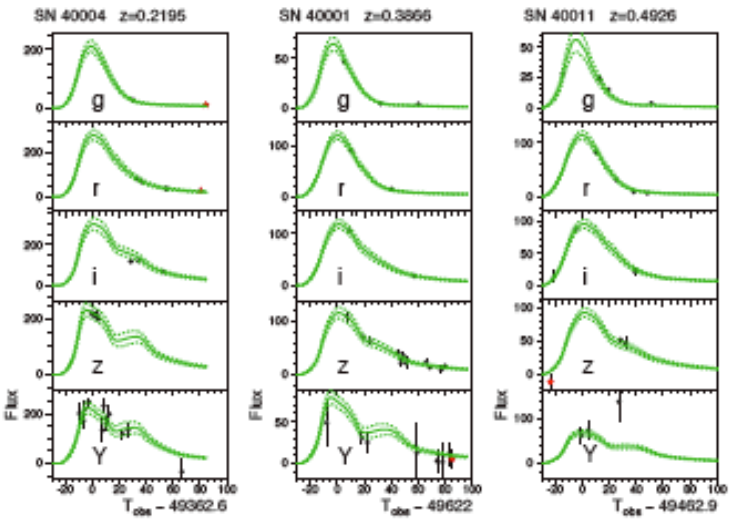
Precision Cosmology: Constraints on Dark Energy

- **LSST will probe the nature of Dark Energy via a distinct set of complementary probes:**
  - **SNe Ia's as "standard candles"**
  - **Baryon acoustic oscillations as a "standard rulers"**
  - **Studies of growth of structure via weak gravitational lensing**
  - **Studies of growth of structure via clusters of galaxies**
  - **Time delays in strong gravitational lenses**

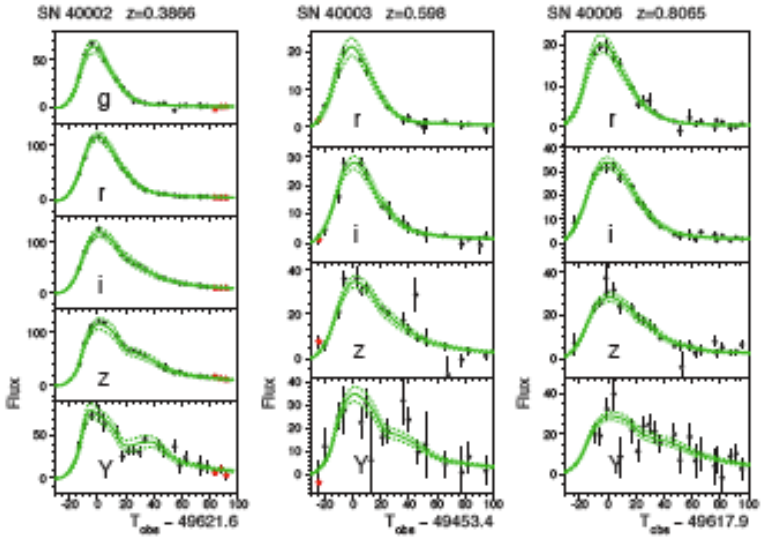
- **In conjunction with one another, this rich spectrum of tests is crucial for reduction of systematics and dependence on nuisance parameters.**

- **These tests also provide interesting constraints on other topics in fundamental physics: the nature of inflation, modifications to GR, the masses of neutrinos.**

Supernova Lightcurve Simulations



Main Survey



Deep Drilling Fields

Hubble Diagrams as a Function of Direction on the Sky

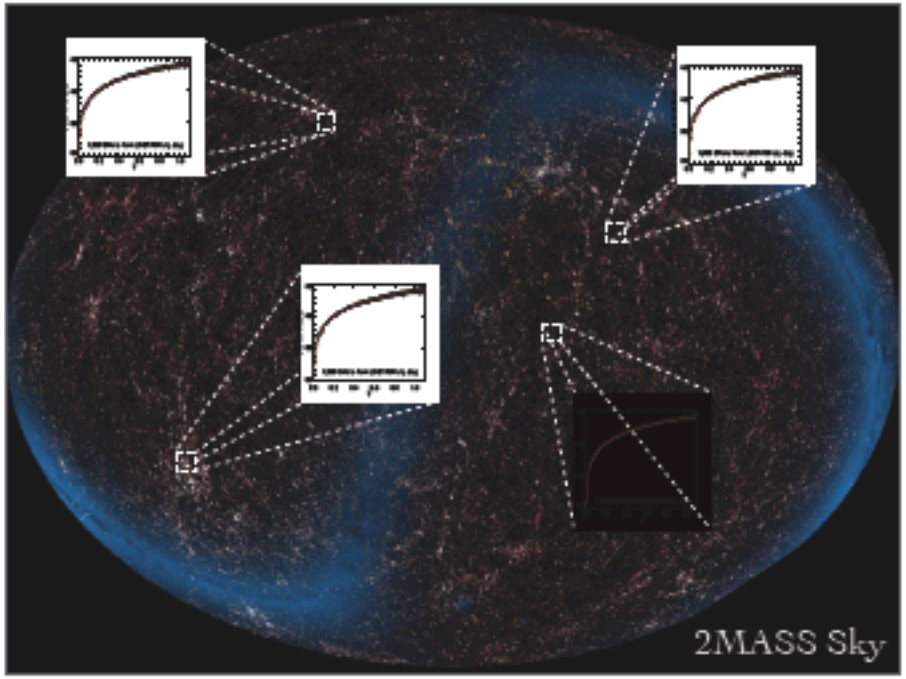
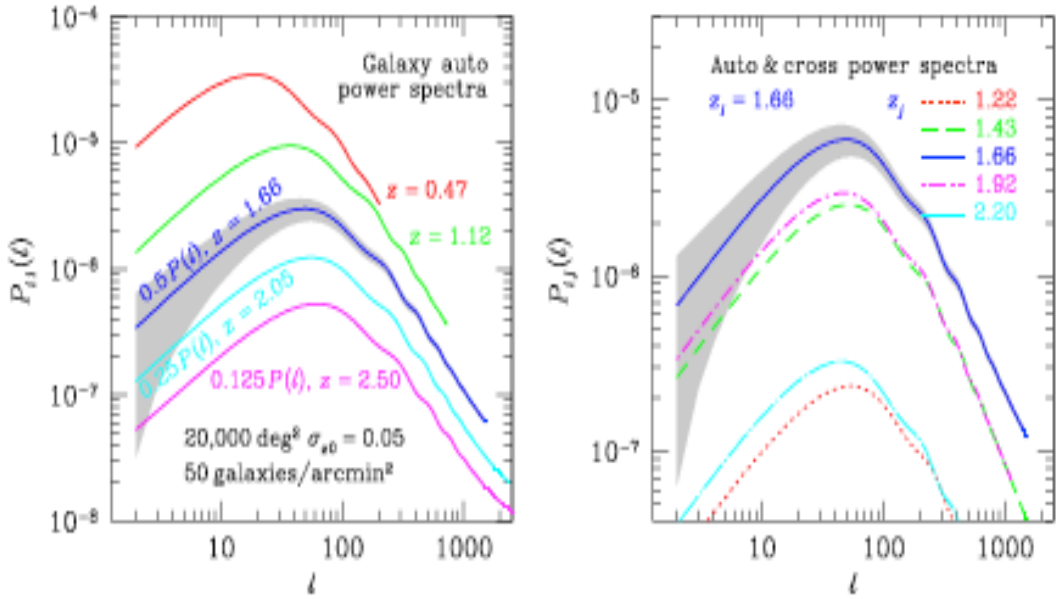
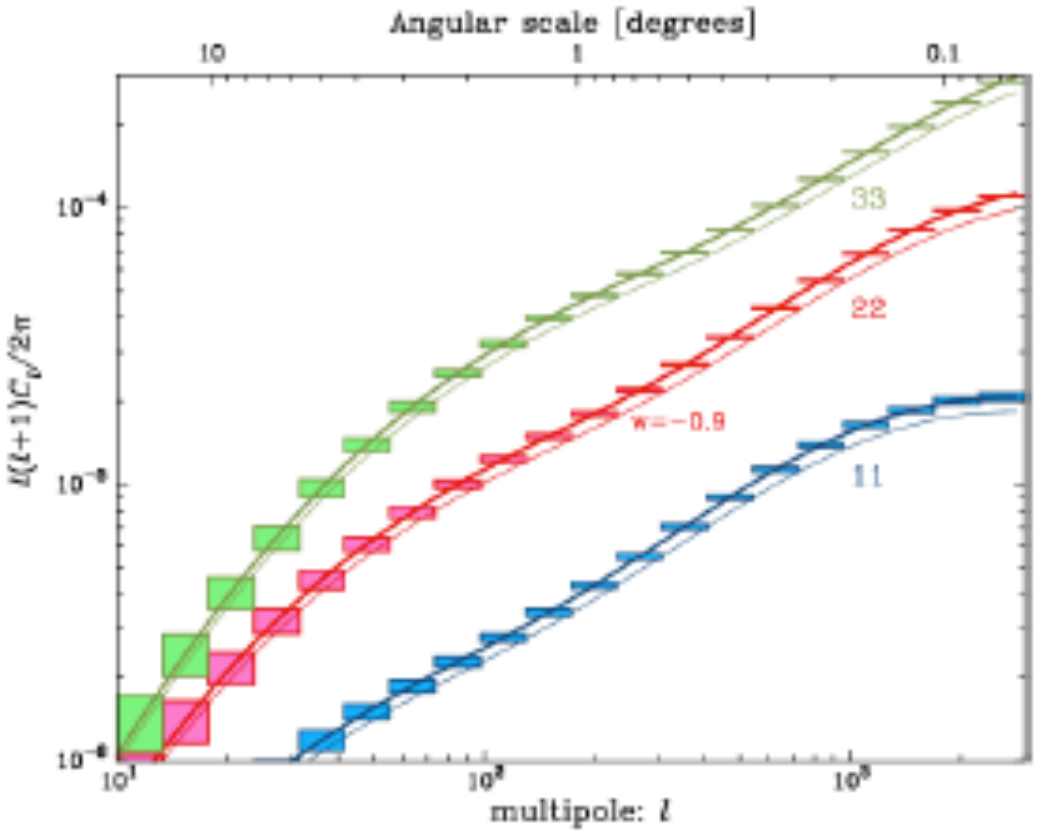


Figure 11.14: Testing the isotropy of dark energy by obtaining SN Ia luminosity-redshift measurements in each of 500 pixels on the sky. Each such pixel of 40 deg^2 will have on the order of 1000 SNe Ia, and cosmological parameters can be estimated from each of these independently. The background sky image is from the 2MASS survey, and shows the distribution of nearby galaxies.

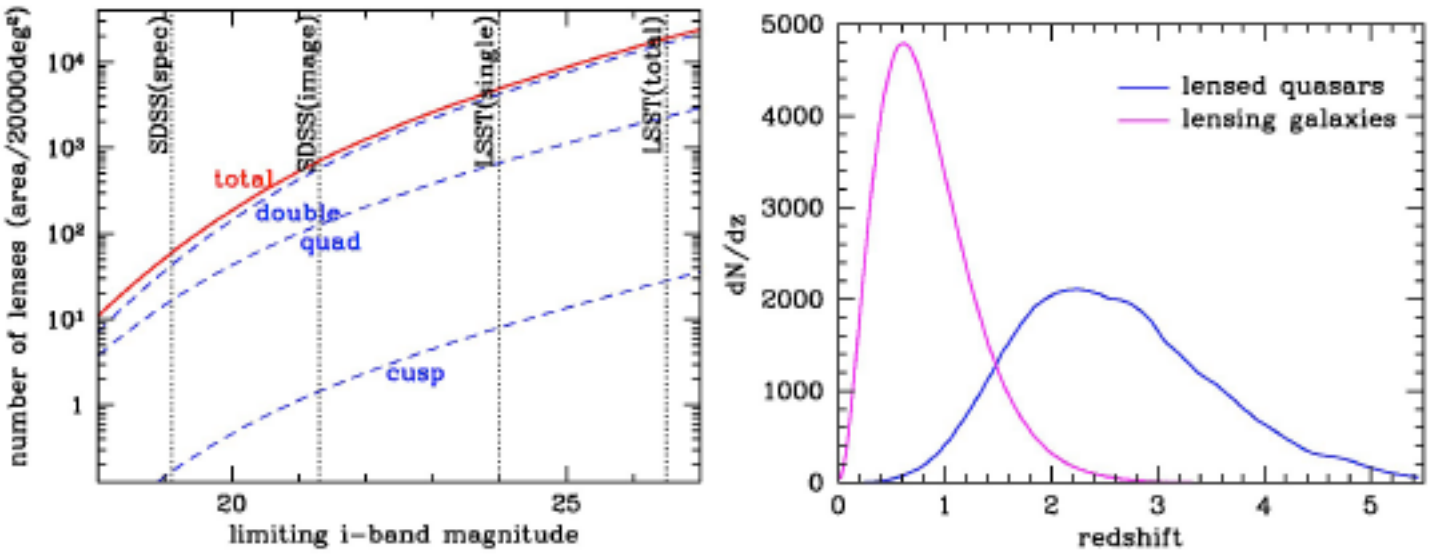
Predictions for Galaxy Auto and Cross Power Spectra



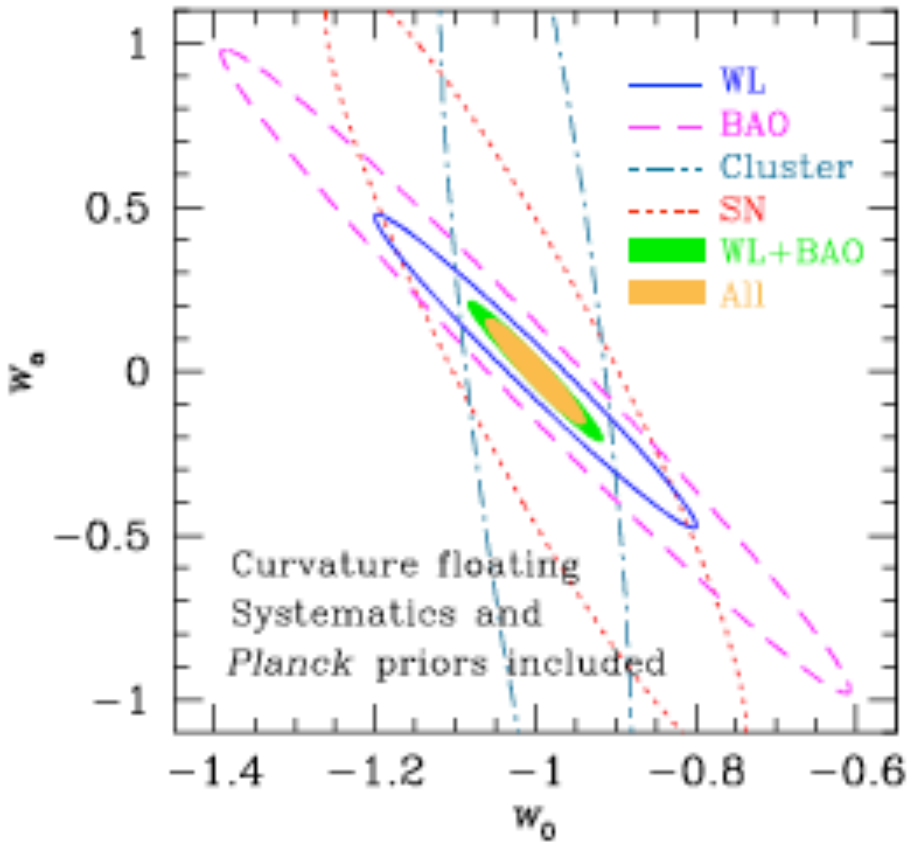
Shear Power Spectra as a Function of Redshift

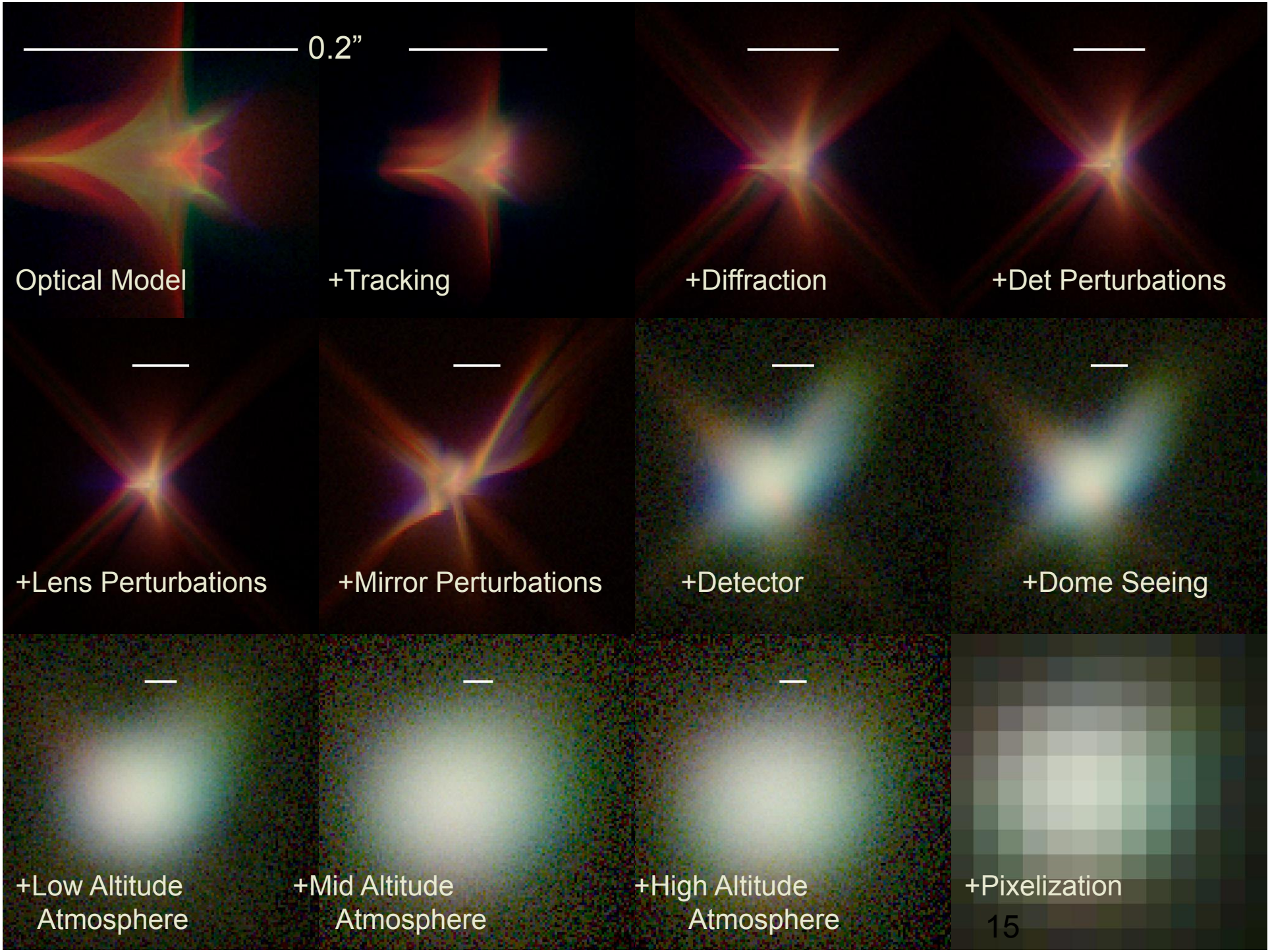


Strong Lensing Sample Size Estimates: Lensed Quasars



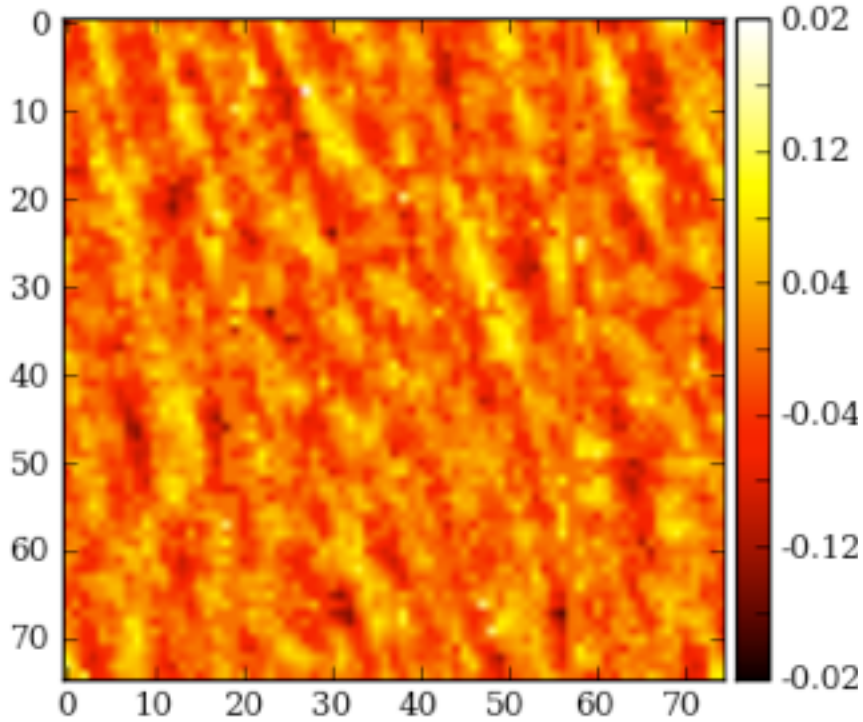
Constraints on the Dark Energy Equation of State



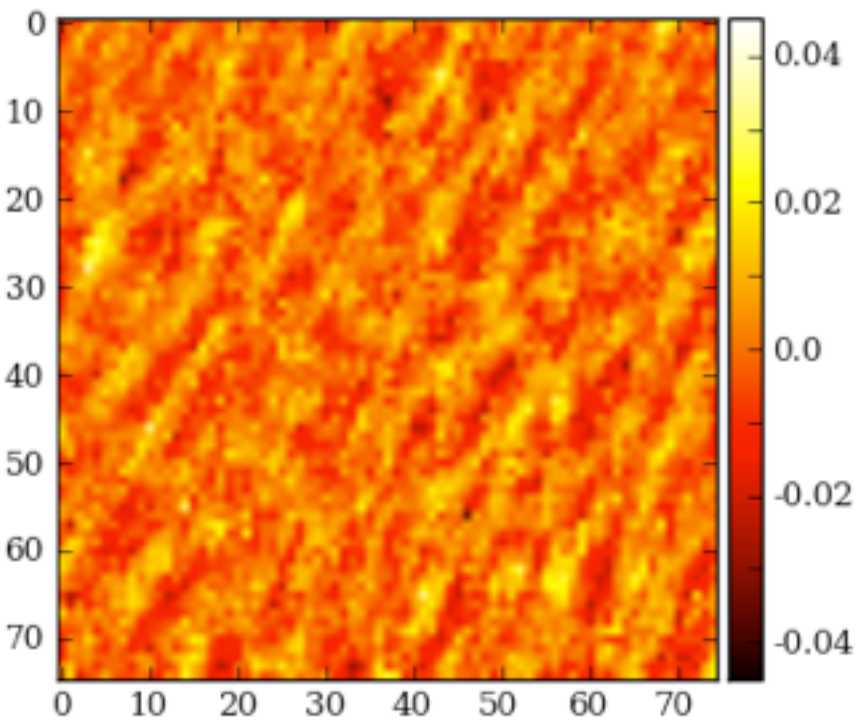

0.2”
Optical Model
+Tracking
+Diffraction
+Det Perturbations
+Lens Perturbations
+Mirror Perturbations
+Detector
+Dome Seeing
+Low Altitude Atmosphere
+Mid Altitude Atmosphere
+High Altitude Atmosphere
+Pixelization

Simulating Ellipticity Contributions from the Atmosphere

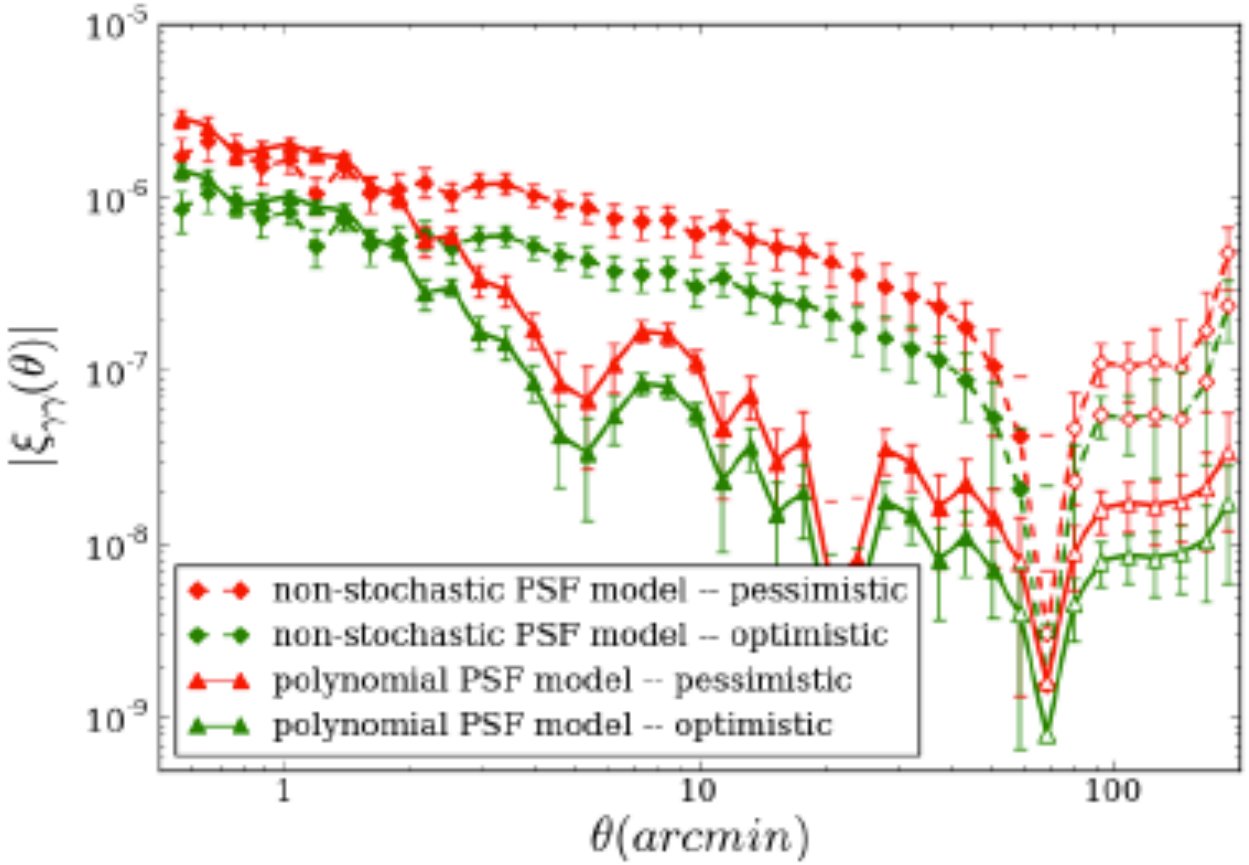
CFHT Data



Simulation



Estimates of Residual Spurious Shear Correlation After PSF Correction



Summary

- The LSST will be a world-leading facility for astronomy and cosmology. A single database will enable a large array of diverse scientific investigations. The project has broad support in the astronomy community, and it is therefore a key component of NSF's long-term plan for the field.

- LSST will measure properties of dark energy via weak lensing, baryon oscillations, Type 1a supernovae, clusters of galaxies, and time delays in strong gravitational lenses. No other existing or proposed ground-based facility has comparable scientific reach.

- The synergy in technical and scientific expertise between the astronomy and HEP communities will be essential to the project's success.

- A detailed initial design is in place for all major components of the system. Appropriate funding from NSF and DOE is in the President's Budget Request for FY14. Assuming Congress passes a budget, the project is on-track to achieve first light in mid-2020.

- We have developed a high fidelity simulator to study detailed systematic effects associated with the atmosphere and the LSST system, and are using that simulator to quantitatively assess our ability to make the precision measurements required for constraining dark energy.